



Jet Propulsion Laboratory
California Institute of Technology

Overview of the 2017-2027 Earth Decadal Survey and Opportunities for Mass Change Observations

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National Academies of Science Earth Decadal Survey Steering Committee

OVERARCHING TASKS

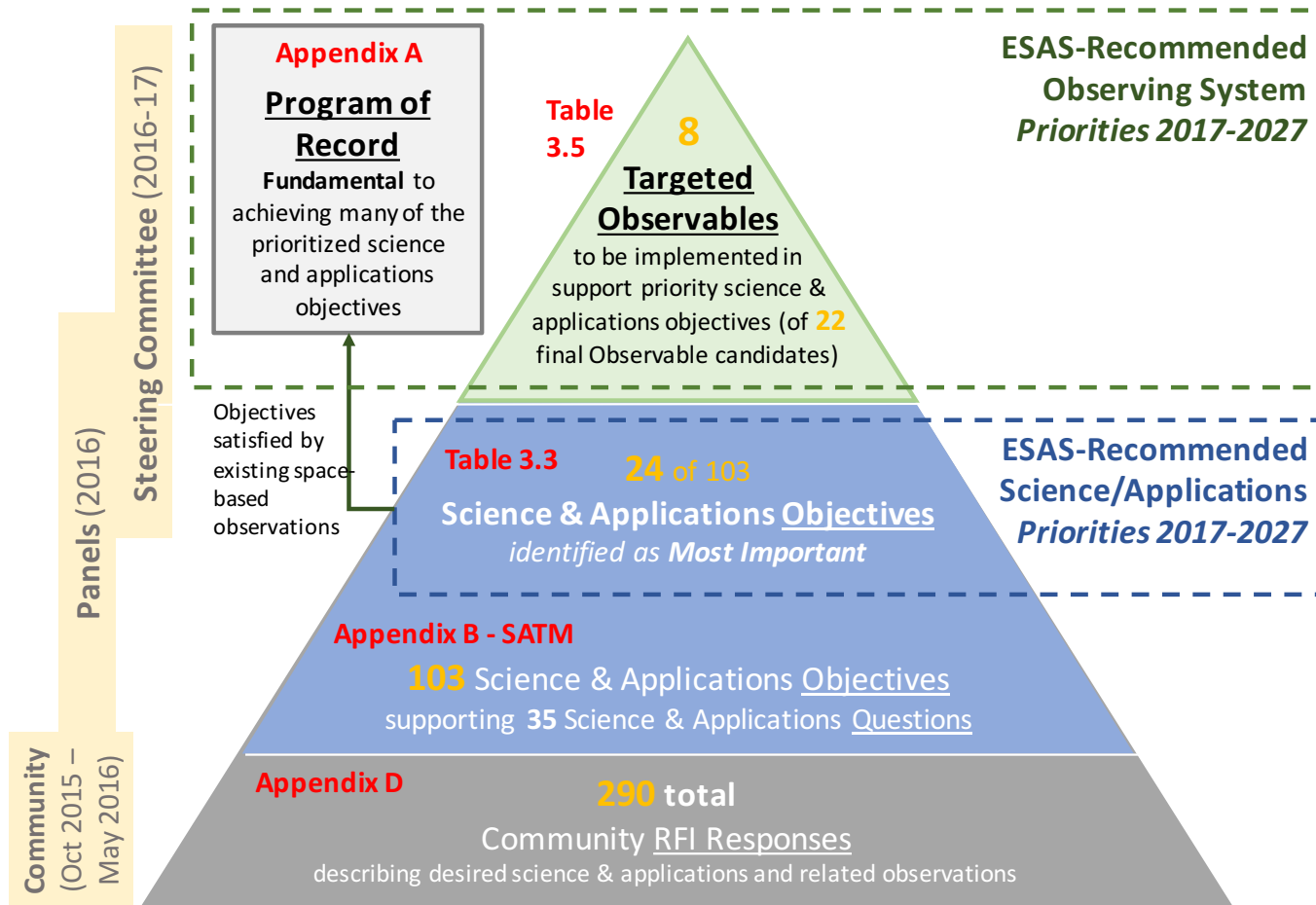
- Assess **progress from 2007**
- Develop a prioritized list of top-level **science and application objectives** for 2017-2027
- Identify gaps and opportunities in the **programs of record** at NASA, NOAA, and USGS
- Recommend approaches to facilitate the development of a robust, resilient, and appropriately balanced U.S. **program of Earth observations** from space

GENERAL & AGENCY-SPECIFIC TASKS

- **Cross-Agency**
 - Enabling activities
 - Partnerships & synergies
- **NASA**
 - Program balance and scope
 - Ventures flight element
 - Decision principles and measurement continuity
- **NOAA and USGS**
 - Non-traditional observation sources
 - On-ramp of scientific advances
 - Research-to-operations
 - Technology replacement/infusion

Path from Science & Applications to Observational Priorities

Blue: Science & Applications; Green: Observables



Recommended NASA Flight Program Elements

Program of Record. The series of existing or previously planned observations, which **should be completed as planned**. Execution of the ESAS 2017 recommendation requires that the total cost to NASA of the Program of Record *flight missions from FY18-FY27 be capped at \$3.6B*.

- **Designated.** A new program element for ESAS-designated cost-capped medium- and large-size missions to address ***observables essential to the overall program*** and that are outside the scope of other opportunities in many cases. Can be competed, at NASA discretion.
- **Earth System Explorer.** A new program element involving competitive opportunities for medium-size instruments and missions serving specified ESAS-priority observations. ***Promotes competition among priorities.***
- **Incubation.** A new program element, focused on investment for priority observation opportunities needing advancement prior to cost-effective implementation, including an Innovation Fund to respond to emerging needs. ***Investment in innovation for the future.***
- **Venture.** Earth Venture program element, as recommended in ESAS 2007 with the addition of a new Venture-Continuity component to provide ***opportunity for low-cost sustained observations.***

DS Designated Observables

TARGETED OBSERVABLE	SCIENCE/APPLICATIONS SUMMARY	CANDIDATE MEASUREMENT APPROACH	Designated	Explorer	Incubation
Aerosols	Aerosol properties, aerosol vertical profiles, and cloud properties to understand their direct and indirect effects on climate and air quality	Backscatter lidar and multi-channel/multi-angle/polarization imaging radiometer flown together on the same platform	X		
Clouds, Convection, & Precipitation	Coupled cloud-precipitation state and dynamics for monitoring global hydrological cycle and understanding contributing processes	Radar(s), with multi-frequency passive microwave and sub-mm radiometer	X		
Mass Change	Large-scale Earth dynamics measured by the changing mass distribution within and between the Earth's atmosphere, oceans, ground water, and ice sheets	Spacecraft ranging measurement of gravity anomaly	X		
Surface Biology & Geology	Earth surface geology and biology , ground/water temperature, snow reflectivity, active geologic processes, vegetation traits and algal biomass	Hyperspectral imagery in the visible and shortwave infrared, multi- or hyperspectral imagery in the thermal IR	X		
Surface Deformation & Change	Earth surface dynamics from earthquakes and landslides to ice sheets and permafrost	Interferometric Synthetic Aperture Radar (InSAR) with ionospheric correction	X		

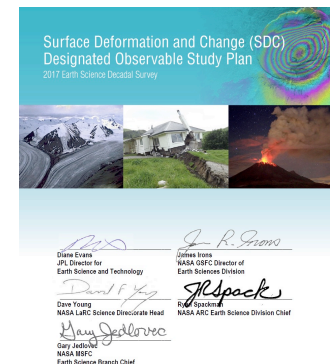
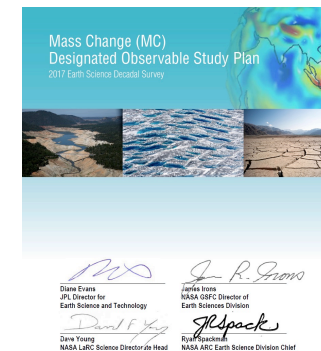
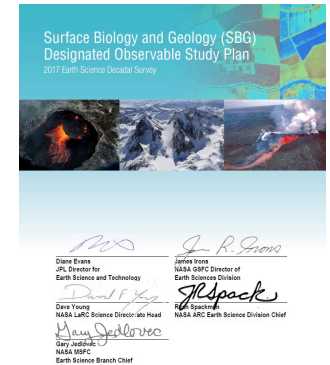
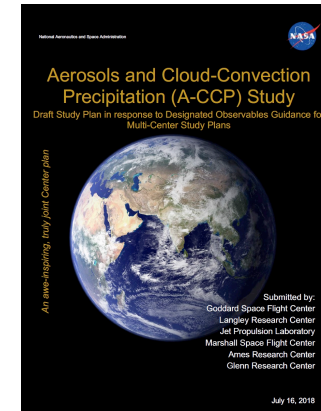
DS Explorer and Incubator Candidates (2)

TARGETED OBSERVABLE	SCIENCE/APPLICATIONS SUMMARY	CANDIDATE MEASUREMENT APPROACH	Designated	Explorer	Incubation
Greenhouse Gases	CO ₂ and methane fluxes and trends, global and regional with quantification of point sources and identification of source types	Multispectral short wave IR and thermal IR sounders; or lidar**		X	
Ice Elevation	Global ice characterization including elevation change of land ice to assess sea level contributions and freeboard height of sea ice to assess sea ice/ocean/atmosphere interaction	Lidar**		X	
Ocean Surface Winds & Currents	Coincident high-accuracy currents and vector winds to assess air-sea momentum exchange and to infer upwelling, upper ocean mixing, and sea-ice drift.	Radar scatterometer		X	
Ozone & Trace Gases	Vertical profiles of ozone and trace gases (including water vapor, CO, NO ₂ , methane, and N ₂ O) globally and with high spatial resolution	UV/IR/microwave limb/nadir sounding and UV/IR solar/stellar occultation		X	
Snow Depth & Snow Water Equivalent	Snow depth and snow water equivalent including high spatial resolution in mountain areas	Radar (Ka/Ku band) altimeter; or lidar**		X	
Terrestrial Ecosystem Structure	3D structure of terrestrial ecosystem including forest canopy and above ground biomass and changes in above ground carbon stock from processes such as deforestation & forest degradation	Lidar**		X	

TARGETED OBSERVABLE	SCIENCE/APPLICATIONS SUMMARY	CANDIDATE MEASUREMENT APPROACH	Designated	Explorer	Incubation
Atmospheric Winds	3D winds in troposphere/PBL for transport of pollutants/carbon/aerosol and water vapor, wind energy, cloud dynamics and convection, and large-scale circulation	Active sensing (lidar, radar, scatterometer); passive imagery or radiometry-based atmos. motion vectors (AMVs) tracking; or lidar**		X	X
Planetary Boundary Layer	Diurnal 3D PBL thermodynamic properties and 2D PBL structure to understand the impact of PBL processes on weather and AQ through high vertical and temporal profiling of PBL temperature, moisture and heights.	Microwave, hyperspectral IR sounder(s) (e.g., in geo or small sat constellation), GPS radio occultation for diurnal PBL temperature and humidity and heights; water vapor profiling DIAL lidar; and lidar** for PBL height			X
Surface Topography & Vegetation	High-resolution global topography including bare surface land topography ice topography, vegetation structure, and shallow water bathymetry	Radar; or lidar**			X

Looking Ahead: The Next Decadal Survey Period

- HQ requested Centers on June 1st to submit multi-Center Study Plans for each of the Five NRC-recommended Designated Observables. Plans were submitted on July 16th.
 - GSFC led Study Plan preparation for the combined Aerosols/ Cloud, Convection and Precipitation (A/CCP) observables
 - JPL led Study Plan preparation of Surface Biology and Geology (SBG), Mass Change (MC) and Surface Deformation and Change (SDC) observables
- The top level goals of the Studies are to
 - Identify and analyze cost-effective observing architectures that leverage international partnerships and commercial sector capabilities and interests, including smallsat constellations.
 - Demonstrate mission concept review readiness by the end of the Study periods (3 – 5 years) for concepts selected by HQ.



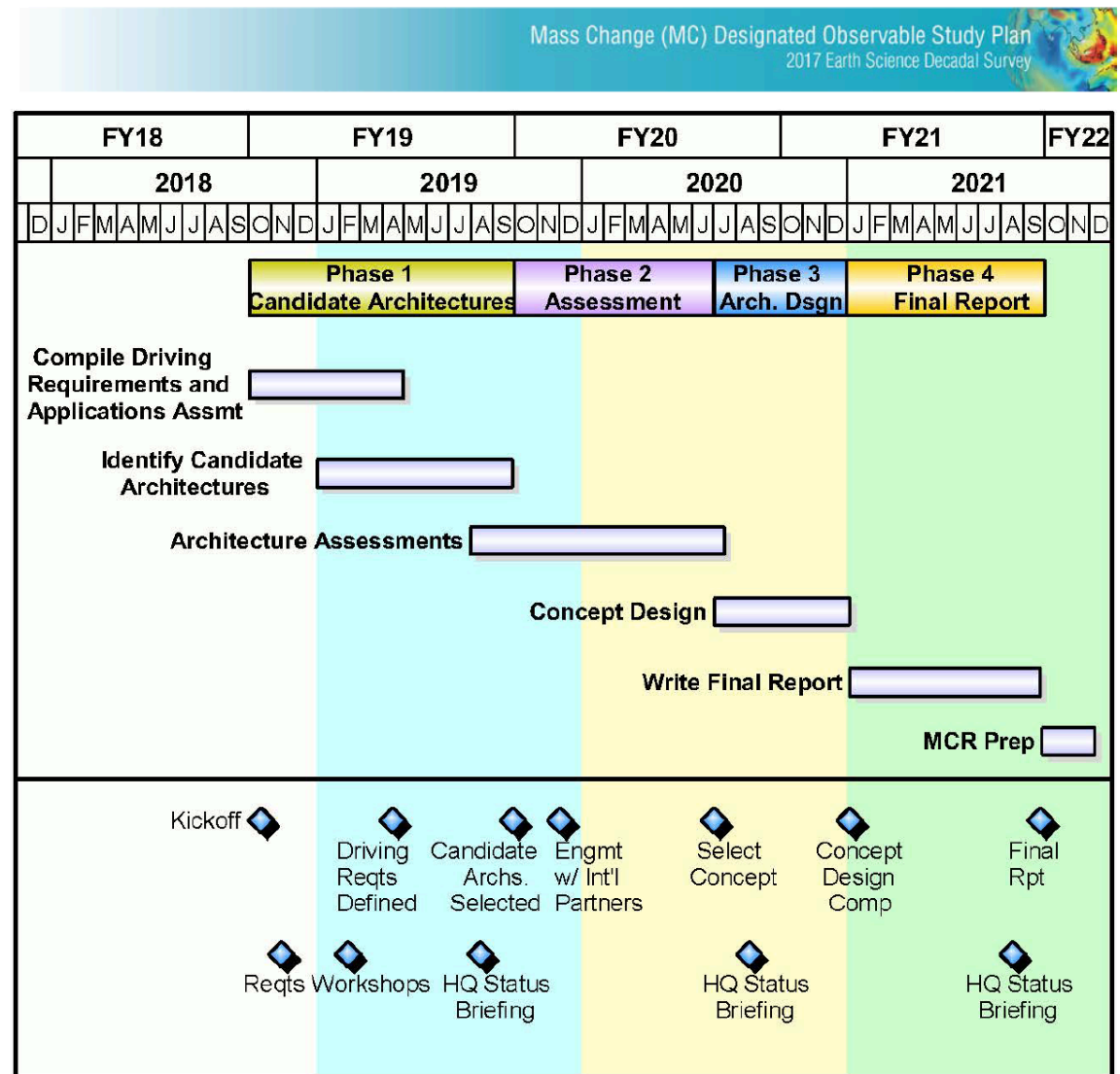
Scope of Designated Observable Studies

The specific objectives of the NASA Architecture Studies are as follows:

- Develop top-level research and application objectives for the targeted DO
- Describe the types of objectives that could potentially address the identified research and application objectives
- Identify potential end users likely to benefit from possible data products and conduct application community assessments.
- Identify potential international and/or interagency partners, and/or private sector participation
- Explore synergies with other DO, ESD, or non-NASA missions
- Identify needed technology refinement efforts, precursor campaigns, and post launch validation
- Examine approaches for incorporating: non-traditional architectures (e.g. commercial solutions, partial solutions, smallsat constellation solutions), possible use of other sampling platforms (e.g. aircraft, suborbital), innovative development approaches and new technologies.
- Explore approaches to developing cost targets for all of the life cycle components of the eventual mission/observing system

Study Schedule

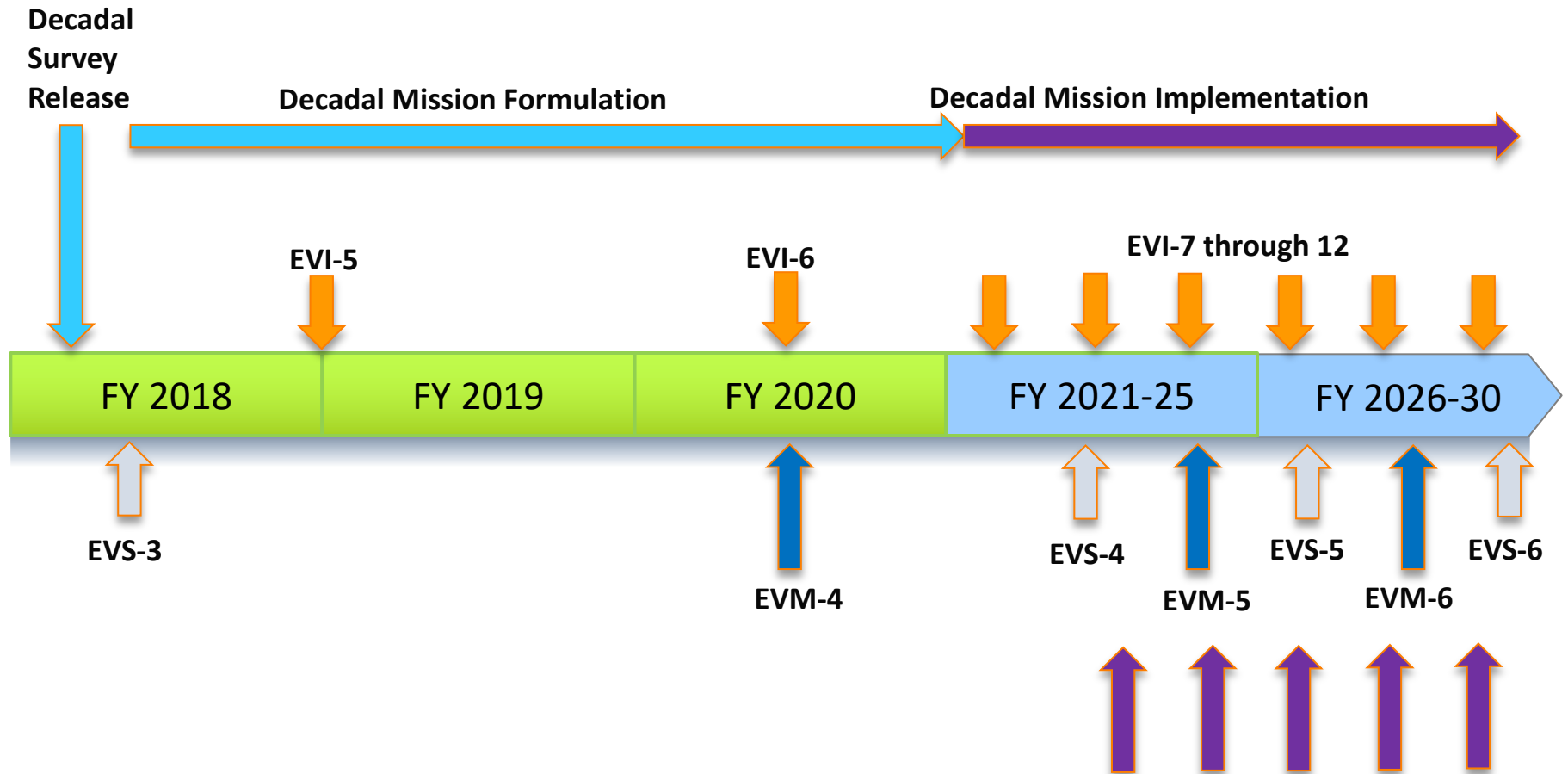
- The final deliverable of the Study is Mission Confirmation Review (MCR) package.





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NASA Opportunities over the Next Decade



- KDP-A's for Designated Observable Missions
- DS Implementation may also include 3 Explorer Class Missions and 3 EV-Continuity Missions